

IS EETA79001 LITHOLOGY B A TRUE MELT COMPOSITION? S. J. Arauza¹ J.H. Jones² L. Le³ and D.W. Mittlefehldt². ¹Dept. of Earth Science, University of California, Santa Barbara, 1006 Webb Hall MC 9630, Santa Barbara, CA, 93106, (arauza@umail.ucsb.edu) ²Mail Code KR, NASA, Johnson Space Center, 2101 NASA Road 1, Houston, TX 77058. ³Jacobs Sverdrup Co., Houston, Texas 77058.

Introduction: EETA79001 is a member of the SNC (shergottite, nakhlite, chassignite) group of Martian meteorites. Most SNC meteorites are cumulates or partial cumulates [1] inhibiting calculation of parent magma compositions; only two (QUE94201 and Y-980459) have been previously identified as true melt compositions. The goal of this study is to test whether EETA79001-B may also represent an equilibrium melt composition, which could potentially expand the current understanding of martian petrology.

Experimental Methods: Sample charges were prepared using a glass powder of Lithology B bulk composition from [2] processed into a paste and mounted on a loop of Re wire. Samples were melted for four hours at 1175 °C, and then dropped to either 1110 or 1120 °C for 2 to 7 days in DelTec furnaces at 1 bar. Oxygen fugacity was set to QFM-2 and controlled by a CO/CO₂ gas mixture, monitored by a remote zirconia cell. Quench temperatures were monitored using a Type B (Pt6Rh, Pt30Rh) thermocouple calibrated to the melting point of gold. Samples were then either drop quenched into water or air quenched.

Table 1: Comparison of starting bulk composition, natural sample, 2 experimental glasses, and Sh-10 [3].

	Start Comp.	Lith. B	LithB- 18	LithB- 19	Sh-10
SiO ₂	49.83	49.38	50.01	51.30	49.90
TiO ₂	1.39	1.38	1.42	1.49	1.21
Al ₂ O ₃	12.55	12.44	11.37	11.15	10.80
Cr ₂ O ₃	0.00	0.00	-	-	0.02
FeO	17.30	17.14	17.41	17.33	19.20
MnO	0.41	0.41	0.42	0.41	0.44
MgO	5.31	5.26	5.16	4.26	4.17
CaO	10.85	10.75	10.69	10.07	9.60
Na ₂ O	1.91	1.89	1.81	1.70	2.08
K ₂ O	0.08	0.08	0.08	0.10	0.28
P ₂ O ₃	1.30	1.29	1.25	1.23	-
Total	100.91	100.0	99.63	99.05	97.70

The narrow temperature range was chosen based on previous experiments: no crystals were present at 1130 °C and the presence of olivine at 1110 °C discouraged against lower-temperature experiments [see below]. Experiments were run at atmospheric pressure (1 bar) due to the assumed low pressure origins of SNC meteorites.

Analytical Methods: Experimental glasses and phases were analyzed using the Cameca SX100 electron microprobe at NASA JSC. Calibration and analyses were run with a current of 20 nA and a voltage of 15 kV. Quenched glasses were analyzed using a 5 µm beam while 1 µm spot analyses were performed on plagioclase, augite, and olivine. All materials were analyzed for Ti, Fe, Mg, Mn, Ca, Na, Si, Al, and P, interpreted as oxides. Analyses of pyroxene and plagioclase were used to compare experimental phases to the natural sample.

Electron microprobe analyses from [3] and [4] were used to construct a phase diagram for SNC meteorites (Fig. 1). Analyses of melts from Shergotty, Zagami, and synthetic EETA79001-A define a cotectic for pigeonite/augite, and a peritectic for low-Ca pyroxene/olivine. The proximity of the lithology B bulk composition (and Shergotty 10 from [3]) to the intersection of these lines is suggestive of an equilibrium melt composition since it lies near a pseudo-invariant point.

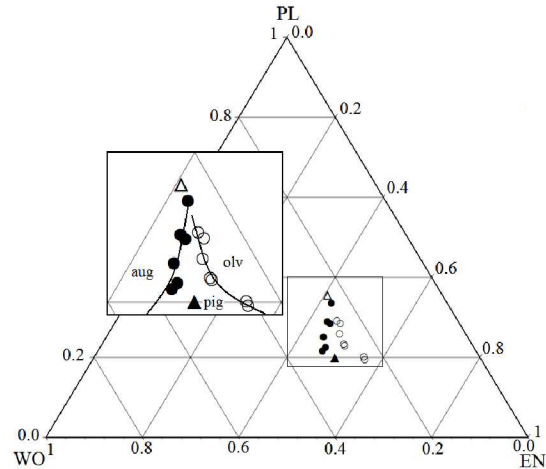


Figure 1: PL-WO-EN pseudo-ternary phase diagram for SNC meteorites from [3] (filled circles) and [4] (open circles). Lithology B bulk composition from [2] is marked by the open triangle and falls close to the pseudoinvariant point defined by the intersection of the aug-pig cotectic and the pyx-olv peritectic. Projection is from [OL, SI].

Results: Two successful 1120 °C crystallization experiments (16 and 18) yielded augite, plagioclase and glass. At 1110 °C, experiments 17 and 19, olivine was also present, which is not found in EETA79001-B.

Pyroxene: Experiments 17, 18, and 19 feature medium-sized (~300 μm), subhedral pyroxene grains growing between euhedral plagioclase crystals. Experiment 16 has smaller, more numerous pyroxenes. Electron microprobe data from [3] are shown on a pyroxene quadrilateral (Fig. 2). Pyroxenes from our experiments cluster around the augite side of the pyroxene solvus. Chemical analysis of augite cores from previous analysis by Dr. David W. Mittlefehldt of EETA79001 are in agreement with our pyroxenes, though the initial description of the natural sample by [5] features both augite and pigeonite. Our crystallization experiments lack pigeonite.

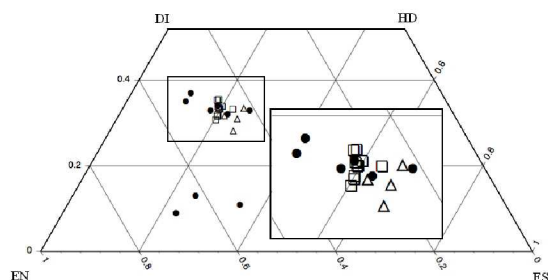


Figure 2: Pyroxene analyses from [3] (black circles), Mittlefehldt's analyses of EETA79001-B (open squares), and Lithology B experiments (open triangles).

Plagioclase: In three of our four experiments, plagioclase occurs in large (500-700 μm) twinned crystals with distinct euhedral and skeletal populations. Euhedral plagioclase crystals are often enveloped by augite and olivine. Experiment 16, however, features the opposite relationship as augite grains have been enveloped by large, blocky plagioclase crystals. This observation is consistent with the natural sample, which features maskelynite (shocked plagioclase) grains in the interstices between clinopyroxenes [5]. Chemical analyses of plagioclase cores (An61-An70) are in general agreement with chemical analyses of maskelynite cores from [5] (An62).

Melt: Melt analyses from crystallization experiments cluster near the lowest-temperature melting point defined by data from [3] and [4].

Olivine: At 1110 $^{\circ}\text{C}$ olivine appears in crystallization experiments. These crystals are also moderately-sized (~300 μm) and grow in the interstices between larger plagioclase grains. Olivine composition ranges from Fo76 to Fo80. Olivine is not found in EETA79001-B.

Discussion: The initial plot of Lithology B melt compositions versus pigeonite-augite and pyroxene-olivine phase boundaries suggested that Lithology B might represent a true equilibrium melt composition. In addition, Lithology B resembles a partial melt of

Shergotty Sh-10 (see Table 1). That our bulk composition plots close to a pseudoinvariant point defined by these phases under these conditions is a strong argument for a melt composition, but modal mineralogy of the experimental samples indicates otherwise.

The presence of olivine in low-temperature experiments is the most important result of this study and there are three possible explanations for the crystallization of olivine. First, the starting composition could have been wrong. The agreement in plagioclase and augite compositions in the experiments and the natural sample validates our choice of an appropriate starting composition. Equilibrium crystallization experiments from this study are nucleating similar phases to the natural sample. Additionally, the bulk lithology from [2] was selected over other possible compositions because it is the least magnesian and therefore least likely to crystallize olivine, which implies that olivine might also be present in similar experiments with different Lithology B starting compositions. Second, the experimental conditions may have been wrong. Pressure and oxygen fugacity conditions for these experiments were chosen based on previous work with SNC meteorites and are accurate to the best of our abilities. The third, and most likely, possible explanation is that EETA79001-B does not represent an equilibrium melt composition.

Conclusions: Results from our crystallization experiments demonstrate that EETA79001-B does not represent a true equilibrium bulk composition. The presence of olivine in the experiments implies that the bulk composition of Lithology B cannot exist in equilibrium conditions at this pressure and temperature without crystallizing olivine, which is not found in the natural sample. Additionally, the presence of pigeonite in EETA79001-B was not successfully reproduced in crystallization experiments. Unfortunately, because Lithology B isn't a true melt, it cannot be used directly to define conditions of the parent material or Martian magmatic conditions.

References: [1] Longhi J. and Pan V. (1989) *LPS XIX*, 451-464. [2] Warren P. and Kallemeyn G. (1997) *Antarctic Meteorite Research*, 10, 61-81. [3] Stolper E. M. and McSween H.Y. (1979) *Geochimica et Cosmochimica Acta*, 43, 1475-1498. [4] Wasylenko L. et al. (1993) *LPSC XXIV*, Abstract #1491. [5] McSween H. Y. and Jarosewich E. (1983) *Geochimica et Cosmochimica Acta*, 47, 1501-1513..